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Title: A Proposed Silicon Vertex Tracker for the PHENIX Detector at Forward Rapidity (U)

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A Proposed Silicon Vertex Tracker for the PHENIX Detector at Forward Rapidity

David M. Lee and Gerd J. Kunde for the PHENIX Collaboration

The current physics reach of the PHENIX Detector in the forward rapidity regions is limited by the lack of a fine grained precision tracker in the central region. We are proposing an upgrade to the PHENIX detector that will provide for the precision measurements of the displaced vertices of heavy quarks that will be used in conjunction with the current muon spectrometers to probe new physics not currently accessible such as, advanced studies of the QGP formation using heavy flavor, improved study of the gluon structure functions in protons, and robust measurements of shadowing in nuclei via measurements of open charm and beauty. We have studied the requirements of such a detector through detailed simulations. Based on the these requirements a conceptual mechanical design and a proposed electronic readout have been developed. The concepts include a specially modified readout chip designed to readout out ministrips of 2-13mm in length that will be matched to the occupancy requirements. We will describe the simulations and the mechanical and electronic concepts.

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(submit to High Energy Physics instrumentation or Nuclear Physics instrumentation)

An upgrade to the PHENIX detector at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory is being proposed that will extend the physics reach to new areas. The complete upgrade proposal will consist of a barrel region to be used in conjunction with the central detectors and two forward regions for each of the two muon spectrometers. The concept is shown in figure 1

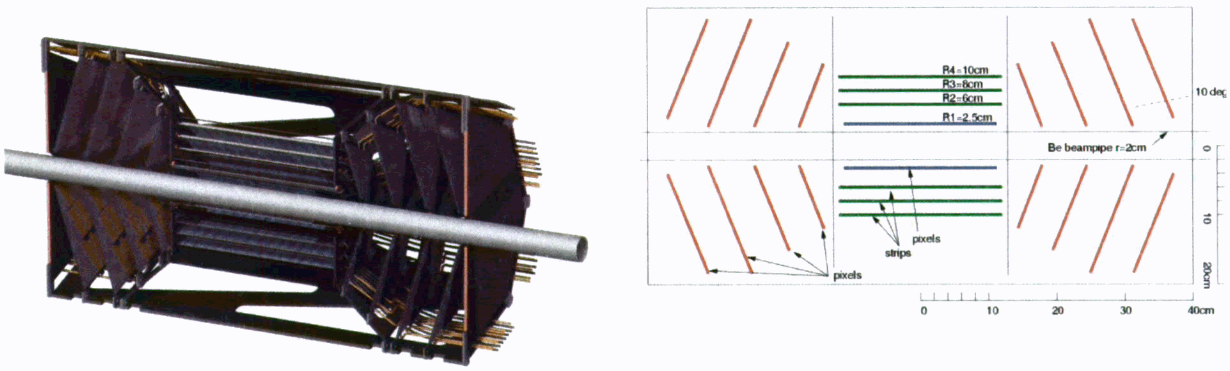

Figure 1. Conceptual design of the silicon detector on the left and a schematic on the right. The Endcap detectors are the 4 layers at the left and right ends of the figure, while the Barrel detector is in the middle.

There are three important and rich physics topics for which the Endcap Si vertex detector is essential:

- The gluon structure function in protons will be accessible with improved signal to noise over a larger range of x via measurements of open charm and beauty in polarized $p+p$ reactions.
- Measurements of shadowing of the gluon structure function in nuclei, via measurements of open charm and beauty in p-A reactions, becomes more robust.
- Advanced studies of the QGP formed in heavy-ion reactions, using the production of heavy flavor. There are several opportunities to enlarge the physics reach beyond PHENIX baseline measurements :
  - Measurement of the p_T spectra of open charm and beauty over a wider range of transverse momenta. The energy-loss of high-p_T heavy-quarks is predicted to be less than for lighter-quarks.
  - Determine the yields of both open-charm and beauty in multiple channels to firmly establish whether heavy-quarks are enhanced in the pre-equilibrium phase.
  - Use the open charm yields to form the ratio (J/ψ)/(open charm) and hence to quantify any observed suppression of the J/ψ.
  - Measurement of the vector mesons and Drell-Yan, with improved signal to noise and better mass resolution than currently possible.

Mechanical Design

The mechanical conceptual design of the silicon tracker has been completed. The results were that we could handle a heat load of 0.7 W/cm**2, operate at room temperature or 0 deg, maintain a stability of 25 microns, and maintain a radiation length of < 1.25% per disk.

Figure 2. Cad drawing of the endcap structure on the left showing the four umbrella type disks with the wedge structure at the right

Electronics Design

We have taken a different approach for the end caps in that we are not using the typical pixel or long strip technology but instead have defined through simulations what the optimum cell size is based on occupancy issues and have a conceptual design of a modified FPIX2 chip that will satisfy our requirements. One advantage of this approach is that we can streamline the development of a suitable chip and tailor it to met this intermediate range between pixels and strips. The design calls for the front end amplifier to handle ministrips between 2 mm and 13 mm in length and 50 microns wide. The initial design shows that we can maintain a noise level < 250 electrons. Since the readout of the FPIX2 can operate at 840Mbits/s we have hopes to be able to use the silicon vertex detector in a first level trigger. Another advantage of this modified design is that we are able to keep the heat load to a minimum.

Simulations

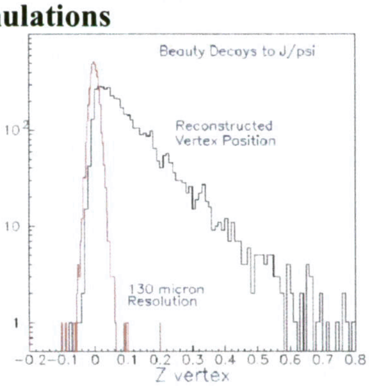

Figure 3. Simulated B->J/Psi decay.

Simulations have been produced that define the capability of our design to see displaced vertices. Shown in figure 3 is the unique process that will allow us to study beauty decays. We are able to achieve 130 microns vertexing resolution even in the forward direction. We have also shown that we can operate in the high multiplicity region of AuAu collisions.